Analysis of Mobile IP for NS-2

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Abstract — **Development of wireless and mobile networks is towards all-IP networks, where Mobile IP is seen as de-facto global standard for handling macro-mobility. One may assume that near soon in all-IP scenario all wireless networks will be using Mobile IP. However, this increases the importance of proper implementation of Mobile IP in NS-2 as the most-used simulation environment in the scientific community. Therefore, in this paper we provide results from the analysis of different implementations of Mobile IP in NS-2 through different simulation scenarios by using different propagation models in the simulator.**

Keywords — **Mobile IP, NS-2, Simulator, Wireless Network.**

I. INTRODUCTION

MOST of the everyday business communication is based on delivering packets between hosts in the Internet. Every host in the Internet is identified by unique IP address that consists of a network and host identifier. The IP datagrams are routed to the network in which the host is located and afterwards to the host itself. The IP address is attached directly to the network where the host is located. What happens if the user with unique IP address in the (wireless) network wants to become mobile? The user will try to establish connection with the same address in the new environment and then a problem occurs, the connection can't be established unless the host enters in the range of different access point that is part of the same network. Mobile IP solves this problem by giving mobile hosts and routers the possibility to forward packets from one location to another. However, we have different transport protocols over the IP, where the most important ones are TCP and UDP. If the host is in the middle of UDP session (e.g. VoIP conversation, Online Gaming, Video session) and it moves in the range of a new access point, the blackout period occurs. In this period the Mobile Host (MH) is not able to receive packets. During this period the MH obtains a new IP address and informs the rest of the entities included in the communication process. In this paper we do detailed analysis of behavior of transport protocols in the Internet with implemented Mobile IP for macro-mobility management.

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The rest of this paper is organized as follows. In section II we give an overview of the main features of the Mobile IP protocol. Section III describes the simulation scenarios in NS-2. Section IV discusses inadequacy of the Mobile IP (MIP) model incorporated in NS2 and gives a possible solution of the issue. In section V the protocol is tested in real simulation environment, presented by two different simulation scenarios. Section VI concludes the paper and gives vision of the further work.

II. OVERVIEW OF MIPv4 PROTOCOL

IETF solution for enabling the IP mobility is to use two IP addresses [1]. One that is permanent or the home address, assigned to the mobile host from his Home Agent (HA) with a rule of endpoint identifier and a temporary address - so called Care of Address (CoA) assigned from the foreign agent in which range the mobile node belongs. The Mobile IP protocol has obligation to track the location of the mobile terminal in order to deliver any packets to it whenever it moves. Mobility functions needed by the mobile host (MH) are administrated at the network layer by two mobility functions implemented in IP routers, Home Agent (HA) in the home network and Foreign Agent (FA) in the foreign network [2]. If the mobile node is in the range of FA, it must first to require a new care of address (CoA). This CoA can be allocated by the FA present in the sub network or by any alternative mechanism such as DHCP. Once the address is obtained, the mobile node updates its home agent. Routing in Mobile IP scenario is shown at Fig. 1.
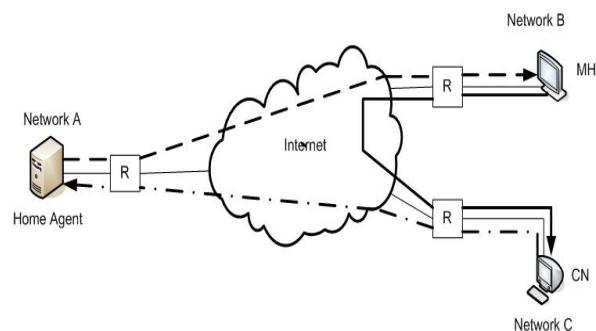

Fig. 1. Mobile IP routing [2].

III. MOBILE IP IN NS2

Mobile IP model for IPv4 networks in NS2 supports wired and wireless networks. It was developed by Sun Microsystems and is based on NS wired model [3]. It includes all Mobile IP entities like HA, FA and MH. The HA and FA are realized as base station nodes. They have registering agent that sends beacon out to the mobile node, sets up encapsulator and decapsulator and replies to solicitations from MHs. The MHs have registering agents,

which receive and respond to beacons and send out solicitations to HA or FAs. The BS routinely broadcasts beacon or advertisement messages out to MH. The MH stores the address of the BS within its service coverage and registers them in a list. When no beacon message is received, the list entry expires itself and is removed. This indicates MH to perform a handover as it leaves the service range of the old BS. Afterwards MH chooses a base-station from the list as its new FA. If the list is empty the MH sends an Agent Solicitation Message. Any BS that receives this solicitation sends an advertisement message to allow the MH to register with it. Fig. 2 shows one simple handover scenario.

The handover starts when MH sends Registration request message. The new BS in the case FA receives and forwards the request to the HA. The HA then updates the MH's CoA in its address binding, and it installs encapsulator to tunnel all future IP packets to the MH via its new BS. Afterwards the HA sends back a Registration Reply message to the BS and in terms informs the MH. If the handover process is successful the MH will register the new CoA. During the handover the packets are dropped until the new connection is established even though the MH could still communicate with its Remote Host (RH) via the old BS. This is result of received beacon message from a new BS, i.e. MH sends registration request and uses this new BS as its new FA.
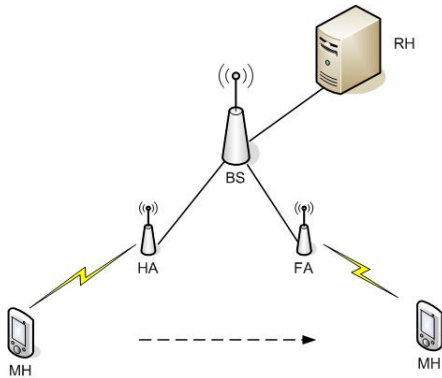

Fig. 2. Generalization of Mobile IP.

In Fig. 2 we can notice that MH is moving from the coverage area of its home agent (HA), which is the BS where the MH is initially registered, towards the coverage area of others BSs that represent Foreign Agents. When an MH decides to switch association data traveling between that MH and its RH will pass through the FA. The packets traveling from RH to MH will pass through FA. Packets from RH in this case will continue to route to HA and afterwards they are forwarded to FA in order to reach the MH. Packets that are forwarded from HA are encapsulated and when they are received by FA they are decapsulated. After the decapsulation they can be forwarded to the MH. Packets that are originating from MH are sent toward FA from where they are directly forwarded to RH.

We can see that there are two methods according which MH can switch associations. The first method is to register with new agent once the lifetime of the current connection expires and the second is to switch association

when beacon is heard. Some issues occur during this handover methods.

In the first case if MH moves with higher rate the frequency of changes associations will be higher then the lifetime expiration rate. In the second case when a new beacon is heard the MH will have indication that is in new subnet. In this case we could have ping-pong effect. In realistic case of two subnets that are overlapping this could result in repeated switching. After the association is changed we do not have any guarantee that the strength of the signal will be better then the previous.

IV. PROBLEMS THAT OCCUR DUE TO INADEQUACY OF NS2 MOBILE IP MODEL

NS2 incorporates the mentioned strategies into its Mobile IP module [4]. This means that MH keeps a list of possible FA's from which has received a beacon. The list is updated every beacon period that usually have one second duration. If the MH does not receive a beacon in the next beacon period the FA will be removed from the list. If the MH receives beacon that is new it will update the list and will assumes that it has moved. The current CoA expires and MH starts the handover procedure with the new FA. There is opinion that this model is good only when all packets are successfully transmitted i.e. when are used Free Space and Two Ray Ground propagation models [5]. The propagation models can be simply described as a circle around the transmitter so if a receiver is within the circle it will receive all the packets, if it is not than it will loses all packets. The most realistic propagation model that is incorporated in ns is the Shadowing model. This model gives us freedom to choose the propagation environment (indoor, outdoor, etc). We know that the received power fades with the distance and that can be modeled more by a random variable that takes into account the distance and the degree of obstruction between BS and MH.

Let's illustrate a real scenario like the one shown at Fig.2 [5] in which we have two base stations HA and FA and one mobile host MH. MH is in the range of HA and there aren't any obstacles between them. FA has poor connectivity with HA. In this scenario the advertisements from HA are always received by HM. This is not case with the advertisements from the FA. We will assume that HA sends its beacons on the second (0.0, 1.0, 2.0 etc) and FA sends its beacons on the half second (0.5, 1, 1.5, 2 etc) [5]. The MH set's its CoA to HA because it hears beacons in every beacon period. This means that HA is in the MH list constantly. NS2 Mobile IP module allows only new BS's to become a new CoA's when a new beacon is heard. If the MH updates its list with new BS it would mean that MH will never set its CoA to HA again.

When the MH hears beacon from FA it will set it CoA to FA until it does not hear advertisement from new BS. If MH connects to the FA at first, because of overlapping ranges of HA and FA, this means that MH has heard the beacon from FA first and has set its CoA at FA. Because of the poor connectivity between MH and FA, MH could hear a beacon from HA and it changes the CoA to HA.

HA sends beacons periodically and this means that after a period it cold hear a beacon from FA. We know that MH updates its list every beacon period and it will register FA

as a new BS. This problem occurs because MH analyzes only the beacon. If we use this Mobile IP module together with Free Space and Two Ray Ground propagation model it will work well because the beacon there ether is received or it is not. This model does not take into consideration the strength of the signal. Palazzi has proposed additional information to be stored in the MH list for each FA and to have the MH keeping a running average of successful received advertisements [5].

$$NewAvg = \alpha \times OldAvg + (1-\alpha) \times beacon\_det\,ected \quad (1)$$

α Is a constant and *beacon_detected* is a binary variable. α Receive values from 0 to 1 and it is used to weight the agent's history against its present every beacon period. If MH receives an advertisement from agent in its list it sets *beacon_ detected* to 1 otherwise it has a value 0. In this model an association switch occurs only when another agent's average is better then the current agent's plus some threshold value T. The FA is removed from the list if some time period of N seconds has elapsed without a detecting advertisement.

V. SIMULATION

We are going to observe different simulation scenarios. In the given scenarios we use TCP traffic.

The network layout of the simulation scenario is shown in Fig. 2. We can see two wired nodes, two base station nodes HA and FA and one Mobile Host. TCP New Reno is used as a transport protocol with max packet size of 1500 bytes. The simulation lasts 70 sec. Mobile Host will start downloading file from RH at 25th second from the simulation start.

After 30 seconds of simulation MH will start moving towards FA with speed of 14m/s. 50s after simulation starts MH will start moving towards HA with speed of 24 m/s.

Simulations are carried with two different propagation models and with different capacity of the links.

In Fig. 3 we can see the behavior of cwnd (TCP congestion window), ssth and RTTxBW in case when the wireless link is the bottleneck. The wireless nodes during the simulation are in 802.11g mode and in this case is used the Shadowing propagation model with $\beta = 2,7$ and $\sigma = 4$.

From Fig. 4 (where we used Two Ray Ground propagation model) one can see the difference from the case when we used the Shadowing model (Fig. 5). However, this difference was expected because of the different presentation of the transmitters in the mobility model.

It is trivial to say that better results could be obtained in the case when we don't have bottleneck in the wireless segment.

If we set the shadowing parameters to $\beta = 2,7$ and $\sigma = 7$ in a scenario when the wireless segment is the bottleneck, we can notice better performances than those shown in Fig. 3, where the performance merit is the throughput i.e. number of packets (bytes) transmitted during a given period of time.
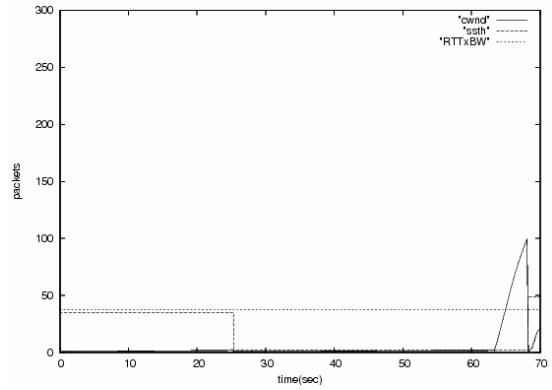

Fig. 3 Graphical presentation of cwnd, ssth, RTTxBW in Mobile IP scenario.
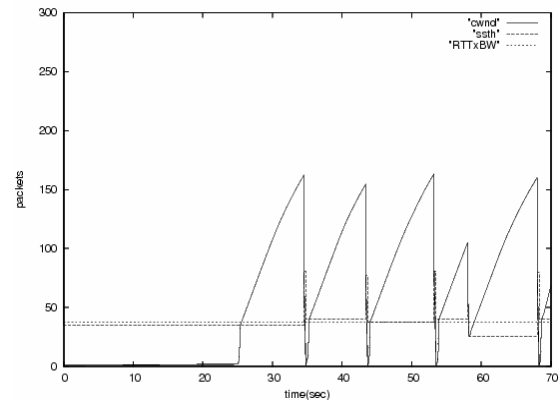

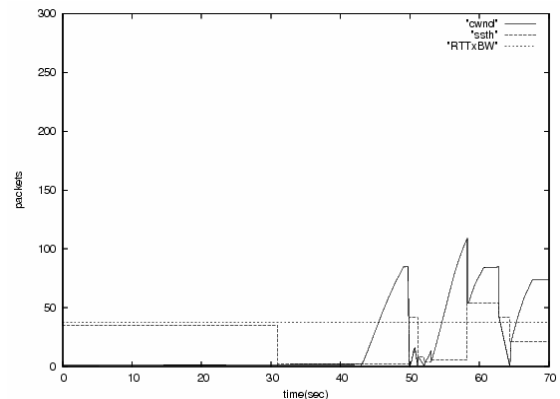Fig. 4. Behavior of cwnd, ssth, RTTxBW when TwoRayGround propagation model is used.

Fig. 5 Behavior of cwnd, ssth, RTTxBW with shadowing parameters $\beta = 2,7$ and $\sigma = 7$; ns 2.28 version.

Lets see what happens if we change the mobile module with the one presented by [5]. In Fig. 6 we have the same simulation environment like it was used when were obtained the results shown in Fig. 3. We can see significant improvement of the behavior of the system. Then, Fig. 7 shows the behavior of the system when we use TwoRayGround propagation model.

Now let's see what happens if we change the propagation model in the same simulation scenario. In Fig. 4 we observe the behavior of the cwnd, ssth and RTTxBW in case when instead of Shadowing we use

TwoRayGround propagation model. Then, in Fig. 8 are shown results gained with improved Mobile IP version. From the simulations we can conclude that improved results are gained if we use the improved Mobile IP model in its both versions, in ns2.28 and ns2.30.

Overall, the conclusion is that different propagation models used with Mobile IP in NS-2 give different resuls. So, this findings point out that such behavior of the Mobile IP module should be taken into consideration when it is implemented in other simulation platforms coupled with, for example, UMTS or WiMAX patches.

VI. CONCLUSION

It is obvious that the core of the future network will be pure IP based that will lead to convergence between various telecommunication systems. This concept will allow deployment of unique backbone network, federating different access technologies [2]. The user should have always access on IP based networks from any access point regardless of the types of fixed or mobile networks and the terminal used. Handling the terminal mobility, Mobile IP provides indeed two fundamental intrinsic proprieties in an IP environment.

Initially developed for the Internet world, Mobile IP can therefore be considered as the expecting federating protocol for a global mobility management approach enabling a smooth integration of all existing and future means of access to an "All IP" core network, and a seamless roaming between heterogeneous access networks. Therefore, research on Mobile IP networks using simulation environments, such as NS-2, will continue further. Hence, it is very important to have reliable simulation environment that can be trusted. In this paper we have showed that Mobile IP implementation in NS-2, regarding the transport protocols, is very dependent upon the propagation model used for wireless interface, and it should be taken into account in all analysis with NS-2 with aim to produce accurate results.

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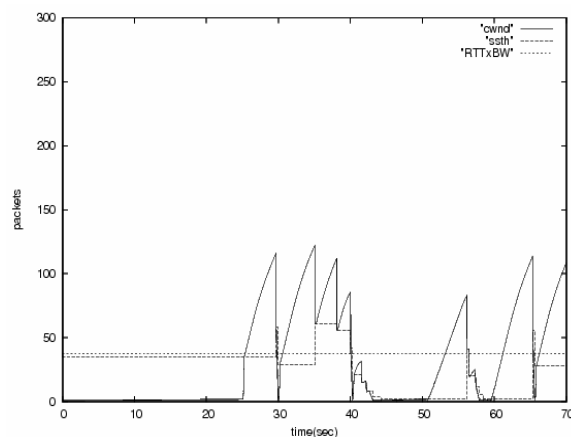[5] Mobile IP for NS-2, http://www.cs.unibo.it/~cpalazzi/mobileip.html

Fig. 6 Graphical presentation of cwnd, ssth, RTTxBW in Mobile IP scenario; improved ns 2.28 version.
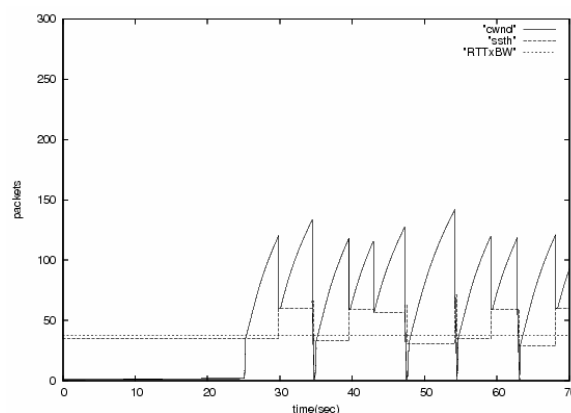

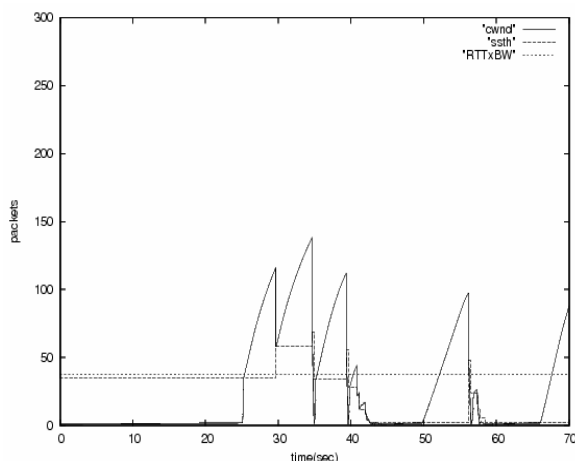Fig. 7 Behavior of cwnd, ssth, RTTxBW with TwoRayGround propagation model; improved ns 2.28.

Fig. 8 Graphical presentation of cwnd, ssth, RTTxBW; ns 2.30 version with improved Mobile IP model.